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(71) Applicant *(for all designated States except US)*: LOUGHBOROUGH UNIVERSITY OF TECHNOLOGY [GB/GB]; Ashby Road, Loughborough, Leicestershire LE11 3TU (GB).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: JENKINSON, Lloyd, Ross [GB/GB]; 8 Cropston Avenue, Loughborough, Leicestershire LE11 0PR (GB). CAVES, Robert, Edward [GB/GB]; 75 Main Street, Normanton on Soar, Loughborough, Leicestershire LE12 5HB (GB).

(74) Agents: McNEIGHT, David, Leslie et al.; McNeight & Lawrence, Regent House, Heaton Lane, Stockport, Cheshire SK4 1BS (GB).

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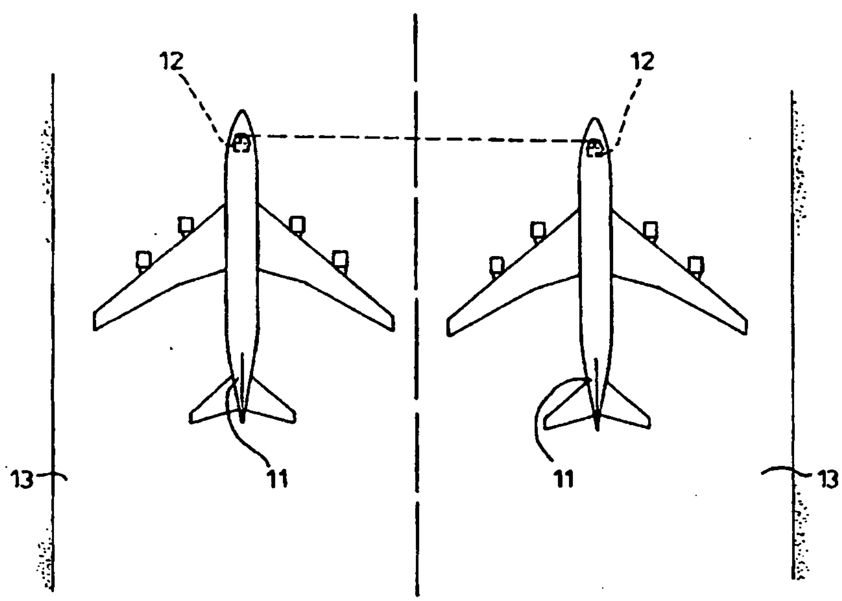

(57) Abstract

There is disclosed a method for operating aircraft, in which two aircraft (11) are controlled by a common control arrangement (12) to fly parallel courses within a common ATC slot.

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OPERATING AIRCRAFT

This invention relates to operating aircraft.

The growth in air passenger transportation is essentially steady at some 5 to 7% per year, effectively doubling in some twelve years.

Clearly, the number of passengers carried to and from any one airport is a matter of the seating capacity of the aircraft used and the frequency of flights. At present, in many cases, and in particular at the principal international airports, the flight frequency is at or near the capacity of air traffic control (ATC) operations, and so larger aircraft are being designed as the only means of coping with the demand.

Unfortunately, the larger aircraft are not viable for a variety of reasons. Prime among these reasons is the requirement that an aircraft is evacuable within 90 seconds. Currently favoured large aircraft designs (capacity twice that of the largest passenger aircraft now flying, the Boeing 747) have full length upper and lower passenger decks - the present 747 range has a forward upper deck bubble only. Timely evacuation demands passengers from a full length upper deck evacuate on slides, but the ground-contacting speed is unacceptable at some 50 kph.

In any event, such double deck designs would require major reconstruction of airport gate arrangements and, unless the wings folded for ground operation, major redesign of apron and taxiway arrangements as well. Folding wings are a mechanical complication best done without.

For these and other reasons aircraft substantially larger than those flying today are unlikely to be operated from existing facilities and within existing safety regulations.

Another solution to the problem would be the construction of new airports, or extending existing airports, both long term and in any event unlikely solutions bearing in mind the difficulties of locating and obtaining planning consent for suitable sites and the very major costs involved.

The present invention provides an alternative solution to the problem of growing traffic volume, while avoiding at least the major snags and, happily, at relatively moderate cost.

The invention comprises a method for operating aircraft, in which two aircraft are controlled by a common control arrangement to fly parallel courses within a common ATC slot.

The aircraft may take off and/or land on parallel runways, and may take off and/or land simultaneously. The aircraft may fly together to pick up parallel automatic landing system guidance beams and then land under independent on-board control using such beams.

One aircraft may slave to the other, and may do so during take off, climb, cruise and/or descent.

The aircraft may have a relative position-error feedback spacing arrangement.

The aircraft may have an absolute position control system, which may be determined by satellite reference and/or by inertial guidance systems such for example as ring-laser gyroscope systems.

The aircraft may fly the same course together from and to parallel runways, and may be, after take off and before landing, more widely spaced apart than the runway separations or fly in close formation to take advantage of vortex air currents.

The aircraft may take off together then fly to different destinations, or may converge from different originating airfields to land together - landing aircraft may fly together in a landing stack.

The invention also comprises equipment for operating aircraft adapted to control two aircraft to fly a parallel course within a common ATC slot.

The equipment may comprise transmitter means adapted for a master aircraft and receiver means adapted for a slave aircraft, said transmitter means transmitting control signals to be received by said receiver means. Said transmitter means may be of such short range or otherwise adapted (as for example by unique "handshake" codes) to transmit signals receivable by said slave aircraft alone (or said slave aircraft and another or other slave aircraft in the event three or more aircraft are flown in a single slot) and not to be received by any other aircraft in the vicinity.

The equipment may comprise transmitter/receiver or transponder means for each aircraft, which may be capable of

(a) reporting the relative positioning of the aircraft;

(b) controlling the adjustment of the relative positioning for station-keeping purposes.

Where a collision avoidance system such as TCAS (Bendix/King) is in operation the equipment may include suitable interfacing arrangements to allow the collision

avoidance system to acknowledge the presence of the other aircraft but issue no warning or initiate no evasive action in regard to it. The equipment might even be incorporated into such a collision avoidance system (or such system incorporated into the equipment). The collision avoidance system would in any event be required to calculate collision avoidance procedures on the basis of two (or more) aircraft flying in formation, possibly avoiding a collision with two (or more) other aircraft also flying in formation.

Embodiments of equipment and methods according to the invention will now be described with reference to the accompanying drawings, in which :-

Figure 1 is a plan view of two aircraft taking off on adjacent, parallel runways;

Figure 2 is a diagrammatic illustration of a flight path for two aircraft;

and Figure 3 is a diagrammatic illustration of a flight path scheme involving three aircraft.

The drawings illustrate methods for operating aircraft 11 (Figure 1) in which two aircraft 11 are

controlled by a common control arrangement 12 to fly parallel courses within a common ATC slot.

Figure 1 illustrates two aircraft 11 taking off simultaneously from adjacent runways 13. Ideally, the runways will be separated by a some 150 metres, but this may not always be possible, and it may be necessary instead to contemplate a single, perhaps a wide, runway on which the aircraft can take off in formation - in echelon, say, as is often done with military aircraft.

The aircraft 11 may fly together to pick up parallel automatic landing system guidance beams from ALS ground stations 14 (Figures 2 and 3) - which should be arranged to be capable of resolving the aircraft on simultaneous approach - and then land under independent on-board control using such beams.

While simultaneous landing is probably best done in that fashion, as errors involved in one aircraft approaching and in that aircraft controlling the other will be additive, thus putting the controlled aircraft outside the permitted error range, it may be the case that the control can be enhanced overall to cover that situation. In any event, for take-off, cruise and/or descent one or more aircraft may slave to any other.

The control arrangement 12 will, for the sake of maximum flexibility, be capable of operating in both master and slave modes - this would mean that aircraft need not be permanently paired, and that control can be passed from one aircraft to the other in flight. At present, take-off is effected manually but (for those aircraft suitably equipped) almost everything else from climb to touch-down is automatic, the occasional landing being effected manually for pilot practice.

Certainly the practice of having dual flight crew on long haul flights - even the practice of having cruise-only capable pilots to give the Captain and First Officer a rest break - may be dispensed with.

The control arrangement 12 can include a relative position-error feedback spacing arrangement, and the nature of that arrangement may depend on the spacing which it is decided should be maintained. The spacing could be so small that an optical system could be effective even in cloud. Radar and collision avoidance bearing and range measuring systems could be used, but, for reasonable spacings, satellite or inertial (e.g. ring laser gyroscope) systems could be used to determine the absolute position of both aircraft, from which relative positioning can be deduced.

The aircraft can, as illustrated in Figure 2, fly the same course together from and to parallel runways 11R and L of airfield I and 11' R and L of airfield II. It would, of course, be possible to land sequentially on a single runway if that is all the destination airfield boasted, and this would be feasible for flights from a busy field like Heathrow to a less busy airport.

However, two aircraft can, as illustrated in Figure 3, take off together from parallel runways 11R and L of airfield I and climb together the cruise height CH then fly separate courses C1 to different airfields II, III. The aircraft on course C can be joined for descent and landing by a third aircraft flying course C" from another airfield, not shown.

Thus the idea of electronically "connecting" two similar aircraft together to be equivalent to one aircraft of twice the size and capacity is seen to have wider application generally to the more efficient use of ATC slots enabling airports to handle larger traffic volumes without drastic changes in ground handling facilities - building an extra close-coupled runway and expanding ground facilities at one airport site will usually be preferable to building an entire new airport to handle traffic with which the first can no longer cope.

Further increase in capacity can of course be accommodated by flying three or four aircraft electronically connected. It is not necessary that the aircraft fly line abreast, but it is probably better to do that, in close-coupled flying, than line astern. Echelon or V-formation flying can take advantage of vortex air currents.

CLAIMS

1. A method for operating aircraft, in which two aircraft are controlled by a common control arrangement to fly parallel courses within a common ATC slot.

2. A method according to claim 1, in which the aircraft take off and/or land on parallel runways.

3. A method according to claim 1 or claim 2, in which the aircraft take off and/or land simultaneously.

4. A method according to any one of claims 1 to 3, in which the aircraft fly together to pick up parallel automatic landing system guidance beams and then land under independent on-board control using such beams.

5. A method according to any one of claims 1 to 4, in which one aircraft slaves to the other.

6. A method according to claim 5, in which one aircraft slaves to the other during take off.

7. A method according to claim 5 or claim 6, in which one aircraft slaves to the other during climb, cruise and/or descent.

8. A method according to any one of claims 1 to 7, in which the aircraft have a relative position-error feedback spacing arrangement.

9. A method according to any one of claims 1 to 8, in which the aircraft have an absolute position control spacing arrangement.

10. A method according to claim 9, in which the absolute position is determined by satellite reference.

11. A method according to claim 9, in which the absolute position is determined by inertial guidance systems.

12. A method according to claim 11, in which the inertial guidance systems comprise ring-laser gyroscope systems.

13. A method according to any one of claims 1 to 12, in which the aircraft fly the same course together from and to parallel runways.

14. A method according to claim 13, in which the aircraft are, after take off and before landing, more widely spaced apart than the runways.

15. A method according to any one of claims 1 to 12, in which the aircraft take off together then fly to different destinations.

16. A method according to any one of claims 1 to 12, in which the aircraft caverage from different originating airfields to land together.

17. A method according to any one of claims 13, 14 and 16, in which the aircraft fly together in a landing stack.

18. Equipment for operating aircraft adapted to control two aircraft to fly parallel courses within a common ATC slot.

19. Equipment according to claim 18, comprising transmitter means adapted for a master aircraft and receiver means adapted for a slave aircraft, said transmitter means transmitting control signals to be received by said receiver means.

20. Equipment according to claim 19, in which said transmitter means are of such short range or otherwise adapted to transmit signals receivable by said slave aircraft alone and not to be received by any other aircraft in the vicinity.

21. Equipment according to claim 19 or claim 20, comprising transmitter/receiver or transponder means for each aircraft.

22. Equipment according to claim 21, in which the transmitter/receiver or transponder means on each aircraft are capable of

a) reporting the relative positioning of the aircraft,

b) controlling the adjustment of the relative positioning for station-keeping purposes.

23. Equipment according to any one of claims 18 to 22, incorporated in (or incorporating) a collision avoidance system suitably adapted to give warning of and if appropriate compute avoidance measures for impending collision.

24. In combination, a dual runway arrangement, two airplanes and equipment according to any one of claims 18 to 23.

25. For operating a method according to any one of claims 1 to 17, from an airport with adjacent, parallel runways or a single runway adapted for dual landing,

equipment according to any one of claims 18 to 23, comprising automatic landing system guidance beam arrangements capable of resolving two aircraft approaching simultaneously.

26. Arrangements according to claim 25, operating at different frequencies for the separate approaches.

27. Arrangements according to claim 25 or claim 26, operating using electronic handshake arrangements for resolving the aircraft.

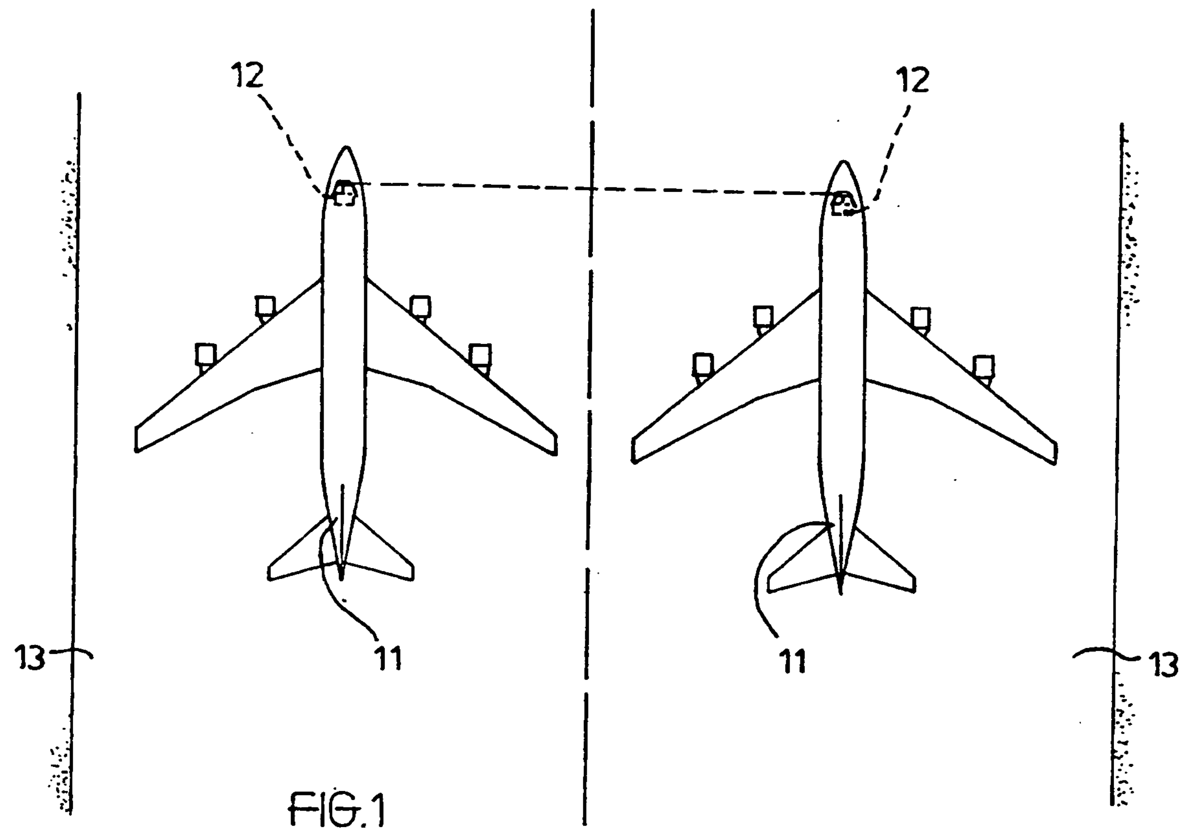

FIG.1

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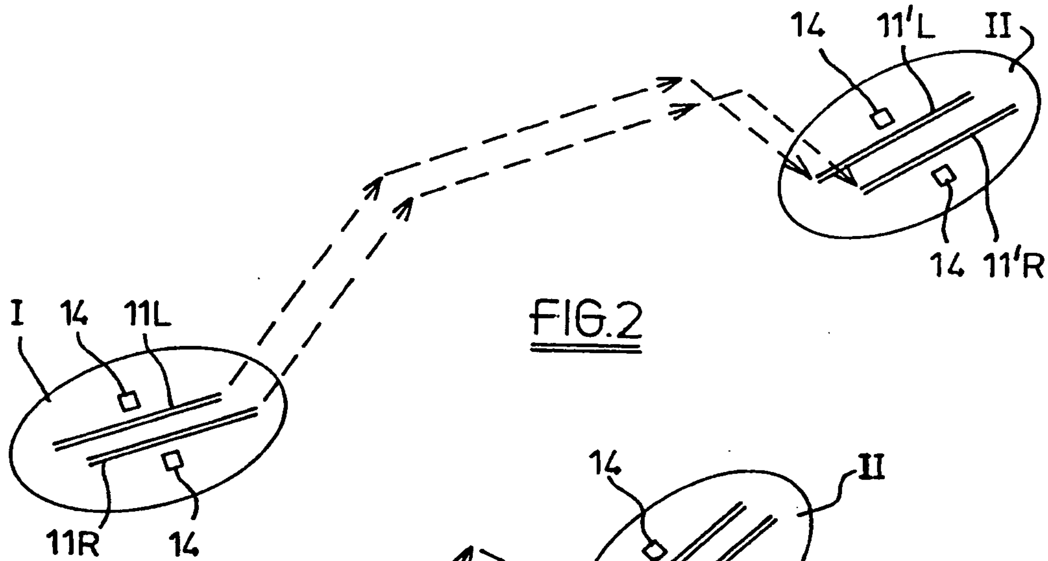

FIG.2

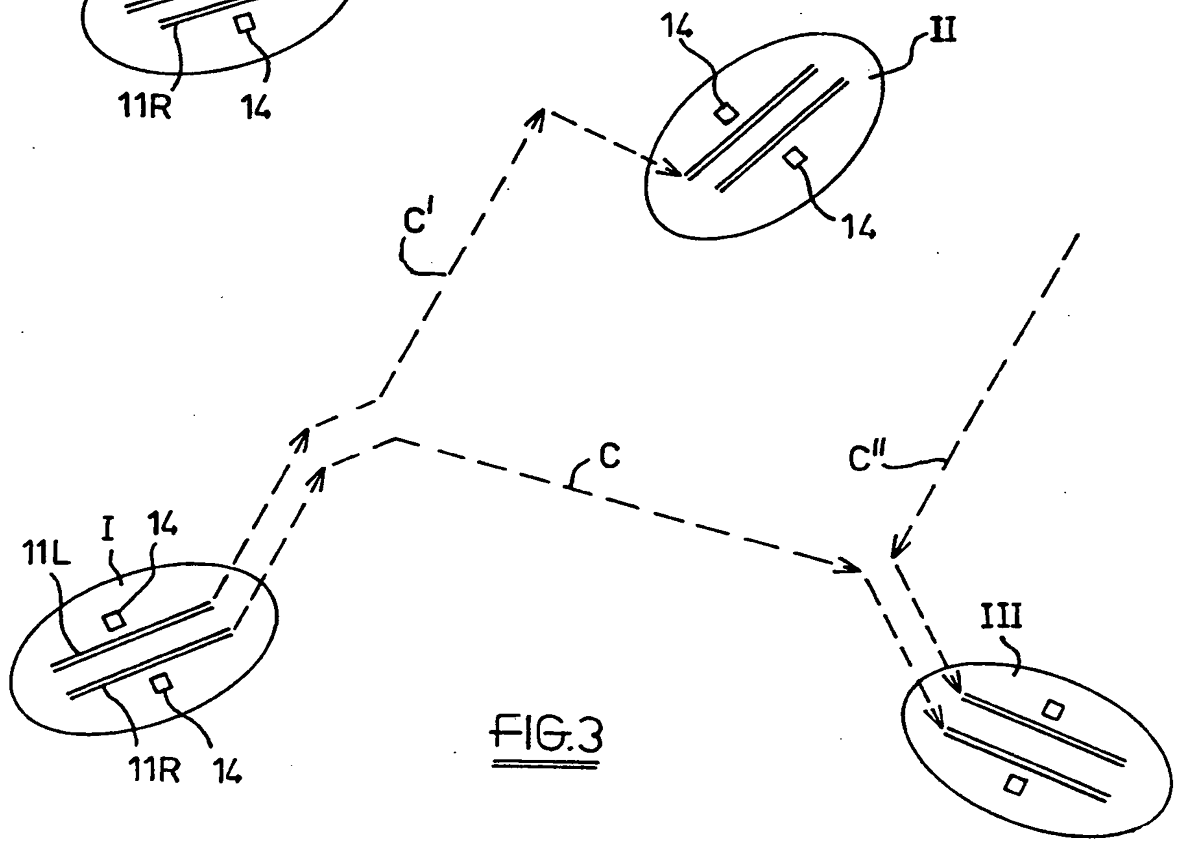

FIG.3